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Title: The Ristra project: Next-generation multi-physics for national-security applications

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The Ristra project: Next-generation multi-physics for national-security applications

Exascale Challenge Problem

- Multi-physics simulations of systems using advanced material modeling for extreme conditions supporting experimental programs at MaRIE
- Multi-physics simulations of high-energy density physics (HEDP) in support of inertial confinement fusion (ICF) experimental programs at NIF
- Routine 3D simulation capabilities to address a variety of new mission spaces of interest to the NNSA complex
- Compile-time configurable abstraction layer (FleCSI) to separate physics method expression from underlying data and execution model implementations
- Rich remap and link capabilities for physics coupling within and between codes
- Demonstrate the use of advanced programming systems such as Legion for scalable parallel multi-physics, multi-scale code development

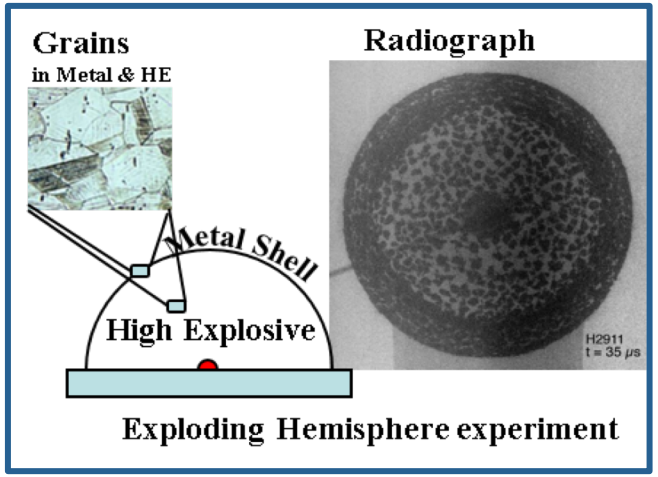
Applications & S/W Technologies

Application codes

- Ristra codes FleCSALE, FUEL, and Symphony

Software Technologies Cited

- FleCSI, Portage, Tangram, Ingen
- Legion, MPI, GasNetEx
- Alpine, ParaView, VTK-m, HDF5
- Kokkos, CUDA, OpenMP, Trilinos
- C++17, LLVM/Clang, Python, Lua



Risks and Challenges

- Performance impact of FleCSI abstraction layer must be managed carefully in the context of dynamic multi-physics problem
- Serial constraints of existing operator split techniques must be reconsidered to achieved scalability at exascale and beyond
- Multi-scale integration of advanced material models in modern unstructured hydrodynamics codes is a research topic
- Scalable storage in support of routine 3D simulations of sufficient resolution is unproven
- Immaturity of advanced programming systems such as Legion

Development Plan

Y1: Released version 1.0 of a production toolkit for multi-physics application development on advanced architectures including FleCSI abstraction layer and Portage remap and link library., Demonstrated low-energy-density problems in FleCSI-based codes FleCSALE and FUEL.

Y2: Released toolkit version 2.0. Demonstrated high-energy-density multi-physics problems in radiation hydrodynamics in the FleCSI-based code Symphony.

Y3: Toolkit release version 3.0. Workflow integration in preparation for Y4 goal.

Y4: ASC L1 milestone demonstrating problem of programmatic relevance on ASC Advanced Technology Systems, with evaluation of productivity, portability, and performance.

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